Program: Biotechnology		
Course Title: Biochemistry		**Course Code: 15EBTC202**
L-T-P: 4-0-0	**Credits: 4.0**	**Contact Hours: 04 Hours/Week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 50	**Examination Duration: 03 Hours**	

Unit I

1. Biochemical Foundation & Carbohydrates

Types of chemical reactions, Solution chemistry. pH (Henderson-hesselbatch equation) Buffers and their Biological importance, carbohydrates- chemical structure and properties classification- Monosaccharide's, Disaccharides, Sugar derivatives, deoxy sugars, amino sugars, and sugar acids, phosphorylated sugars, structure and properties of polysaccharides, Homopolysaccharides, Heteropolysaccharides - Peptidoglycan, Glycosaminoglycans, Glycoconjugates, Glycobiology . Biological importance of carbohydrates. **07 Hours**

2. Lipids

Definition and classification of lipid – simple, compound and derived lipids. Structure, classification and properties of fatty acids, Essential and non-essential fatty acid with physiological importance. Structure and physiogical functions of phospholipids, Sphingolipids, cerebrosides and gangliosides. Steroids- Structure and functions of cholesterol,. Eicosanoids, lipoproteins and terpenes. Vitamins-classifications and functions **05 Hours**

3. Amino acids and Proteins

Definition, Classification and properties of amino acids, reactions, rare amino acids, essential and nonessential amino acids with physiological importance. Peptides - Definition of peptide bond, Biologically important peptides. Proteins – Classification- primary, secondary- Alpha helix, Beta sheets, tertiary and quaternary proteins-hemoglobin. Ramachandran plot, polypeptide sequencing- Edman degradation, Chemical synthesis of Peptides. **05Hours**

4. Nucleic acids

Structure and properties of purines, pyrimidines, nucleosides and nucleotides. Nucleic acids- Structure of DNA, RNA -Types, **03 Hours**

Unit II

5. Carbohydrate metabolism

Glycolysis-aerobic and in anaerobic pathway, Energy yield of glycolysis Regulation of glycolysis-metabolic and hormonal. Fates of pyruvate. Glycogen - synthesis and degradation. Regulation of glycogen metabolism. Gluconeogenesis, Pentose phosphate pathway. Significance of pentose phosphate pathway and regulation. Production of Acetyl-CoA, Reactions of Citric acid cycle, Anaplerotic reactions, regulation of citric acid cycle. Glyoxylate cycle, Electron transport chain, ATP synthesis, shuttle systems and Oxidative phosphorylation. Cyclic and Non-cyclic Photophosphorylation and Calvin Cycle (C3) in plants Disorders of carbohydrate metabolism. Production of microbial polysaccharides; industrial and Medical application of exopolysaccharides.

10 Hours

6. Metabolism of Amino acids

General reactions of amino acid metabolism, urea cycle, amino acid biosynthesis-aspartate and glutamate family and degradation of aromatic amino acid - phenylalanine and tyrosine, metabolic disorders of amino acid metabolism, biosynthesis of plant substances and neurotransmitters, Environmental and Industrial Significance of Amino acid metabolism.

05 Hours

7. Metabolism of Fatty acids

Fatty acid oxidation, biosynthesis of fatty acids, Ketone bodies, phospholipids and spingolipids cholesterol biosynthesis, Regulation, metabolic disorders of lipid metabolism. Environmental and Industrial Significance of lipid metabolism **05 Hours**

Unit III

8. Metabolism of Nucleic acids

Biosynthesis and degradation of purines and pyrimidines, salvage pathway, uric acid production, regulation, metabolic disorders of nucleic acid metabolism. **05 Hours**

9. Biological Membranes And Transport Mechanism

Composition and functions of biological membranes (fluid mosaic model) – Proteins, Carbohydrates, Glycoprotein and glycolipids, Membrane transport - Passive transport and Active transport. Mechanism of Na+ and K+, glucose and amino acid transport. Role of transport in signal transduction processes. **05 Hours**

Text Books

1. David L. Nelson, Michael M. Cox, Lehninger Principles of Biochemistry, Sixth Edition, W.H. Freeman, 2012.
2. Jeremy M. Berg, John L. Tymoczko, Lubert Stryer. , Biochemistry, 7th revised International edition, Palgrave MacMillan, 2011.

Reference Books

1. Donald Voet and Judith G. Voet. , Biochemistry, 4th edition, Wiley; , 2010
2. Geoffrey L. Zubay, Principles of Biochemistry , Edition: 4th, William C Brown Pub, 1999.

Scheme for End Semester Assessment (ESA)

UNIT	8 Questions to be set of 20 Marks Each	Chapter numbers	Instructions
I	3 Questions to be set of 20 Marks Each	1, 2, 3,4	Solve Any 2 out of 3
II	3 Questions to be set of 20 Marks Each	5,6,7	Solve Any 2 out of 3
III	2 Questions to be set of 20 Marks Each	8,9	Solve Any 1 out of 2

Program: Biotechnology		
Course Title: Enzyme Technology		Course Code: 17EBTC201
L-T-P: 4-0-0	Credits: 4.0	Contact Hours: 04 Hours/Week
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hours: 50	Examination Duration: 03 Hours	

Unit I

1. Introduction to enzymes

History, nomenclature, classification of enzymes, sources of enzymes, properties of enzyme, Types of specificities, mechanism of enzyme action-Lock and Key model and Induced fit model, Enzyme catalysis -Acid base catalysis, covalent catalysis, metal ion catalysis, Proximity and orientation effects. Mechanism of coenzymes (NAD/NADP,FAD/$FADH_2$,PLP, Coenzyme A, TPP, Biotin) **07 Hours**

2. Purification of enzymes

Objectives and strategies in enzyme purification, choice of source-plant, animal and microbial, purification of intracellular and extracellular enzymes (Comprehensive flow sheet for enzyme purification),methods of homogenization, methods of separation-Enzyme fractionation by precipitation (using Temperature, salt, solvent, pH, etc.), liquid-liquid extraction, ionic exchange, gel chromatography, affinity chromatography and other special purification methods., Methods of characterization of enzymes; Analysis of yield, purity and activity of enzymes. Molecular weight determination-SDS-PAGE, MALDI-TOF **08 Hours**

3. Enzymatic techniques

Enzyme assay, Enzyme and isoenzyme measurement methods with examples(fixed incubation and kinetic methods) Methods for investigating the kinetics of Enzyme catalyzed reactions-Initial velocity studies, rapid-reaction techniques, Standardization and optimization methods, stability and activity of enzymes **05 Hours**

Unit II

4. Enzyme Kinetics and Enzyme Inhibitions.

Kinetics of single substrate reactions; Derivation of Michaelis -Menten equation, turnover number; K_{cat} value, determination of Km and Vmax, Line Weaver Burk plot, Eadie Hofstee plot, Hanes woolf plot, Importance of Km & Vmax; Enzyme inhibitions- reversible, competitive, uncompetitive and non-competitive inhibitions and kinetics, allosteric and irreversible inhibition. Substrate inhibitions, Multi-substrate reactions-ordered mechanisms, random mechanisms, Ping-pong mechanism. Allosteric enzymes and regulation - The Monad - Changeux - Wyman model (MCW) and The Koshland - Nemethy - Filmer (KNF) model, Feedback regulation and covalent regulation.

07 Hours

5. Enzymes Of Medical Importance

Acetylcholinesterase, angiotensin converting enzyme (ACE), ACE Inhibitors, HMG Co A reductase inhibitors, pseudocholinesterase, 5'-nucleotidase (5NT), glucose-6-phosphate dehydrogenase (GPD), CKisoforms, immunoreactive trypsinogen (IRT) and chymotrypsin; amylase isoenzymes.Importance of enzymes in diagnostics, Enzyme pattern in diseases like Myocardial infarctions, (SGOT, SGPT & LDH). Isoenzymes (CK, LD, ALP). Enzymes in immunoassay techniques, Therapeutic enzymes. **07 Hours**

6. Enzyme Immobilization

Techniques of enzyme immobilization, adsorption - matrix entrapment- encapsulation- cross-linking - covalent binding - examples; whole cell immobilization and their application, kinetics of immobilized enzymes, effect of solute, partition & diffusion on the kinetics of immobilized enzymes, uses of immobilized enzymes, Design of Immobilized Enzyme Reactors- Stirred tank reactors(STR), Continuous Flow Stirred Tank Reactors (CSTR), Packed- bed reactors (PBR), Fluidized-bed Reactors (FBR); Membrane reactor **06 Hours**

Unit III

7. Industrial Applications of enzymes:

Enzymes used in detergents, use of proteases in food, leather and wool industries, uses of lactase in dairy industry, methods involved in production of glucose and maltose syrup from starch (using starch hydrolyzing enzymes),Glucose from cellulose, glucose oxidase and catalase in food industry, **05 Hours**

8. Enzyme transformation and Enzyme Biosensors

The design and construction of novel enzymes- Enzyme Engineering and site directed mutagenesis, Designer enzymes, synzymes, Biocatalysts from extreme Thermophilic and Hyperthermophilic microorganisms (extremozymes) Elements of biosensors, Design of enzyme electrodes and their applications as biosensors in industry, health care and environment.

05Hours

Text Books

1. David L. Nelson, Michael M. Cox, Lehninger Principles of Biochemistry. , 6, W.H. Freeman, 2012
2. Trevor Palmer, 2. Enzymes: Biochemistry, Biotechnology and Clinical Chemistry, 1, East-West Press Pvt. Ltd, 2004

References

1. Laurence A. Moran, Raymond S. Ochs, J. David Rawn, and K. Gray Scrimgeour. , Principles of biochemistry., 3, Prentice Hall, 2002
2. Faber, Biotransformation in Organic Chemistry , 4, Springer, 2000
   Aehle W, Enzymes in industry- production and applications, 3, Wiley-VCH, 2007
3. Nicholas .C. Price and Lewis Stevens, Fundamentals of Enzymology , 3, Oxford University Press , 1991

Scheme for End Semester Assessment (ESA)

UNIT	8 Questions to be set of 20 Marks Each	Chapter numbers	Instructions
I	3 Questions to be set of 20 Marks Each	1, 2, 3	Solve Any 2 out of 3
II	3 Questions to be set of 20 Marks Each	4,5,6	Solve Any 2 out of 3
III	2 Questions to be set of 20 Marks Each	7,8	Solve Any 1 out of 2

Program: Biotechnology		
Course Title: Bioprocess Plant Design and Economics		Course Code: 18EBTE301
L-T-P: 3-0-0	Credits: 3.0	Contact Hours: 03 Hours/Week
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hours: 40	Examination Duration: 03 Hours	

Unit I

1. Introduction to Process Design Development

Design project procedure, design information from the literature and other sources of information, flow diagrams, preliminary design, and comparison of different processes, Equipment design and specialization, factors affecting the investment.

06Hours

2. General Design Considerations

Marketability of the product, availability of technology, Health and safety hazards, raw materials, human resources, loss prevention Environmental protection and utilities, site characteristics, plant location, plant layout, plant operation and control, utilities, structural design, storage, materials handling, materials and fabrication Selection, optimum design and design strategy. Waste disposal, physical treatment, chemical treatment and biological treatment, govt. regulations and other legal restrictions, community factors. Safety and hazard control measures.

10 Hours

Unit II

3. Cost Analysis and Manufacturing Cost

Cost Analysis: Factors involved in project cost estimation. Cash flow diagrams for the industrial operation, Cumulative cash position, factors affecting the Investment and production cost, Different methods employed for the estimation of the capital investment. Estimation of equipment cost by sixth tenth rule, Cost index. Marshall and swift installed – equipment indexes, Engineers News-Record construction index, Nelson –Farrar refinery construction index. and Chemical Engineering plant cost index Manufacturing Costs: Direct Production costs, indirect cost and fixed charges (including depreciation, taxes, insurance, rental costs etc.)

10 Hours

4. Bioprocess Economics:

Economic analysis for the production of following Products.(Historical Perspective, Fermentation Technology, Recovery of product and process economics of following products)High volume, low value products. (Citric acid, Ethanol and Amino acids etc) Medium volume, medium value products.(Antibiotics, Crude Enzymes and Vitamins etc)

- Low volume, high value products. (MAb, purified Enzymes and Therapeutic proteins etc)

06 Hours

Unit III

5. Profitability Analysis and Optimization Technique

i) Importance of profitability analysis in investment decision making. Different Methods for calculating the profitability. Minimum Acceptable Rate of return. Methods that Do not consider Time value of money.

04 Hours

ii) General procedure to find the optimum conditions, factors affecting the optimization, comparison of analytical and graphical methods. Linear programming, Simultaneous Equations and dynamic programming

04 Hours

Text Books:

1. Peters and Timmerhaus, Plant Design and Economics for Chemical Engineers, McGraw Hill 5th edition, 2004.
2. Chemical Engineering plant design, Frank C Vilbrandt and Charles E Dryden , McGraw Hill 4th edition, 1959

Reference Books:

1. Rudd and Watson, Strategy of Process Engineering, Wiley, 1987.
2. Backhurst, J.R And Harker, J. H - Process Plant Design, Heieman Educational Books, (1973).
3. Biochemical Engineering Fundamentals, James E Baily David F Oillis. McGraw-Hill 2nd Internat Edition

Scheme for End semester assessment (ESA)

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I	3 Questions to be set of 20 Marks Each	1, 2	Solve Any 2 out of 3
II	3 Questions to be set of 20 Marks Each	3,4	Solve Any 2 out of 3
III	2 Questions to be set of 20 Marks Each	5	Solve Any 1 out of 2

Program: Biotechnology		
Course Title: Environmental Biotechnology		Course Code: 18EBTE404
L-T-P: 3-0-0	Credits: 3.0	Contact Hours: 03 Hours/Week
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hours: 40	Examination Duration: 03 Hours	

Unit I

1. Introduction

Issues and scope of Environmental Biotechnology, Environment and Biotechnology, Areas of applications for Biotechnology. Microbes and Environment, Genetically modified organisms and Legislation. **03 Hours**

2. Waste Water Treatment

Sources of water pollution, Waste water characteristics: Physical, Chemical and Biological characteristics. Chemical Oxygen Demond (COD) and Biochemical Oxygen Demond (BOD). Introduction to physical and chemical waste water treatment methods. Biological wastewater treatment methods: Aerobic suspended growth treatment processes (Activated Sludge Process, aerared lagoons etc), Aerobic attached growth treatment processes (Trickling Filter, Rotating Biological contactors), Anaerobic suspended growth treatment processes- contact digestors, packed column reactors, UASB. **12 Hours**

Unit II

3. Solid waste Management

Basic aspects, Generation of solid wastes, general composition of Municipal solid waste, On site handling, storage and processing, Collection of solid wastes. Solid waste processing techniques and equipments. Recovery of biological conversion products from solid waste such as composting, sanitary landfilling, recycling, vermicomposting, incineration. Solid waste management for energy recovery-Biogas production, processing of lignocellulosic waste biomass for ethanol production

10 Hours

4. Bioremediation

Uses of bacteria for bioremediation, bioremediation of aromatic and aliphatic hydrocarbons, PCB dechlorination, immobilization techniques for bioremediation, biosorption & bioaccumulation, genetic engineering of microbes for bioremediation. Phytoremediation-plants capable of assimilating heavy metals **05 Hours**

Unit III

5.Bioleaching

Bioleaching using microbes, role of Thiobacilli, direct & indirect bioleaching, copper extraction by leaching, dump leaching **05 Hours**

6. Environmental Impact Assessment

Introduction, Scope and history of EIA, Need of Environmental Impact assessment. Stakeholder and public involvement, Identification and quantification of environmental effects and Environmental Impact statement (EIS) **05 Hours**

Text Books:

1. Metcalf and Eddy, Wastewater Engineering, International Edition, McGraw-Hill, 1991
2. George Tchobanoglous, Hilary Theisen and Rolf Eliassen, Solid Wastes, McGraw Hill Kogakusha

Reference Books:

1. Colin Ratledge, Basic Biotechnology , Cambridge Pub, 2001
2. Indu Shekhar Thakur, Environmental Biotechnology, IK Pub, 2006
3. Pradipta Kumar Mohapatra, Environmental Biotechnology, IK Pub, 2006

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UNIT	8 Questions to be set of 20 Marks Each	Chapter numbers	Instructions
I	3 Questions to be set of 20 Marks Each	1,2	Solve Any 2 out of 3
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III	2 Questions to be set of 20 Marks Each	5,6	Solve Any 1 out of 2

Program: Biotechnology		
Course Title: Bioinformatics		Course Code: 19EBTC301
L-T-P: 4-0-0	Credits: 4.0	Contact Hours: 04 Hours/Week
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hours: 50	Examination Duration: 03 Hours	

Unit - I

1.Database

Introduction, meaning of databases, types of databases, Primary Database: NCBI, Genbank, DDBJ, EMBL. File formats, Secondary Database: PROSITE, PIR, UNIPROT, BLOCKS, Pfam, specialized databases: metabolic pathway database, Structure Database: PDB, MMBD, CATH, SCOP, Ligand Database, Enzyme database, human disease database, microbial and viral genome database, structure visualization tools.

7 Hours

2.Pairwise Sequence Alignment

Meaning and significance of Sequence alignment, Pairwise sequence alignment, Global alignment, Local Alignment, overview of methods, Methods & Algorithms-dot matrix, dynamic programming, substitution matrices, gap penalties, FASTA, BLAST, PSI-BLAST & PHI-BLAST.

8 Hours

3.Multiple Sequence Alignment

Meaning of Multiple Sequence Alignment, Global Multiple Sequence Alignment: Progressive Alignment methods, Iterative methods, Local Multiple sequence Alignment, Significance of Multiple Sequence Alignment, Multiple Sequence Alignment editors. Motifs and Patterns analysis

5 Hours

Unit - II

4.Molecular Phylogenetics

Meaning of phylogenetic analysis, Meaning & significance of evolutionary trees, Rooted and unrooted trees, Elements of phylogenetic Models, Phylogenetic Data Analysis, Distance based methods: Neighbor Joining (NJ) method, Fitch-Margoliash (FM) method, Minimum Evolution (ME) method, Character based methods: Maximum parsimony, Maximum Likelihood; Tree Evaluation methods, Phylogenetic Softwares

7 Hours

5.Gene Prediction

Prokaryote and Eukaryote gene prediction, Prokaryote and Eukaryote promoter site prediction Gene Prediction tools, Genomic database, Next Generation Sequencing.

5 Hours

6.Protein Prediction

Protein structures: Secondary Structure: Alpha helix, beta Sheets, phi & psi angles, Ramachandran plots. Protein Secondary Structure Prediction, Tertiary Structure Predictions: Homology modeling, Protein analysis software: Physicochemical parameters, binding site, sub-cellular location, protein stability, patterns

. **8 Hours**

Unit - III

7.In-silico Drug Designing-I

Introduction to traditional drug designing, Introduction in-silico drug designing approach, Methodology for in-silico drug designing: Structure based and Fragment based drug designing, Steps in drug designing: Target identification, target validation, lead identification and validation, different tools used for drug designing, molecular Modeling

5 Hours

8.In-silico Drug Designing-II

Identification of ligands, Lipinski's rule, Virtual Screening, Process of Docking, Quantitative structure-activity relationship (QSAR), Physical and Chemical basis of receptor ligand interactions, ADMET property analysis. **5 Hours**

Text Books

1. Andreas D. Baxevanis, B. F. Francis Ouellette, Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, 3rd, Wiley-Inte, 2005
2. David Mount, Bioinformatics: Sequence and Genome Analysis , 2nd, Cold Sprin, 2004

Reference Books

1. P. Rastogi, N. Mendiritta, S. C. Rastogi, Bioinformatics: Methods and Applications: Genomics, Proteomics and Drug Discovery, 4th, Prentice-H, 2013.
2. Anand Solomon K, Molecular Modelling and Drug Design , 1st, MJP Publis, 2015
3. Richard Durbin, Sean R. Eddy, Anders Krogh, Biological Sequence Analysis: Probabilistic Models of Proteins and Nucleic Acids, 1st, Cambridge , 1998

Scheme for End semester assessment (ESA)

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I	3 Questions to be set of 20 Marks Each	1, 2, 3	Solve Any 2 out of 3
II	3 Questions to be set of 20 Marks Each	4,5,6	Solve Any 2 out of 3
III	2 Questions to be set of 20 Marks Each	7,8	Solve Any 1 out of 2

Program: Biotechnology		
Course Title: Bioprocess Control and Automation		**Course Code:19EBTC302**
L-T-P: 4-0-0	**Credits: 4.0**	**Contact Hours: 4 hours/week**
ISA Marks:50	**ESA Marks:50**	**Total Marks:100**
Teaching Hours:50	**Examination Duration:3 hrs**	

Unit I

1 Instrumentation & Process Dynamics: Introduction to Measurement of important physicochemical and biochemical parameters in bioprocess. Methods of on line and off line estimation of biomass, substrates and products. Brief introduction to typical automatic control system and its components. Open loop and closed loop control systems.

05 Hours

2 First & Second Order Systems: Mathematical representation of physical systems. Transfer function representation of linear first order systems, Examples: mercury in glass thermometer & Liquid level system. Mathematical forms of standard Input function/Forcing Functions such as Step input, Impulse Input, Linearly increasing Input and Sinusoidal Input. Response of first order system for step input, Features of step response, Response of linearly increasing input. Conceptual numerical. First Order Systems in Series: Interacting and Non-Interacting systems & their Transfer function representation. Second Order Systems: Transfer function representation of Second order systems, Example: Pneumatic Control Valve.

10 Hours

Unit II

3 Controller and Final Control Elements: Different types of controllers-P (Special case of P-controller i.e ON-OFF controller), PI, PD, PID controllers. Derivation of Transfer Functions of different types of controllers. Final control element: The role of Final control Element in control system. Example: Pneumatic Control Valve: Working of Pneumatic control valve, Types of Pneumatic Control Valves i.e. Air to close & air to open.

10 Hours

4 Block Diagram Reduction: Block diagram representation of control systems, Block diagram reduction in case of Servo and Regulatory control systems. Reduction of block diagrams for single input & Single output systems (SISO) & Multiple Input & Multiple Output Systems (MIMO), Problems on block diagram reduction.

05 Hours

5 Block Diagram Reduction (MIMO systems): Analysis of Multiple Input Multiple Output Systems**:** Introduction to Multiple Input & Multiple Output Systems (MIMO), Examples of MIMO systems.Analysis of MIMO systems considering only one Input at a time while other Inputs are Suppressed. Considering only one output at a time while other outputs are Suppressed. Problems on block diagram reduction considering MIMO systems.

05 hours

Unit III

6 Transient response of different controllers for Servo & Regulatory control Problems: Transient response of P, PI, PD & PID controllers for servo and regulatory problems. The determination of offset in all cases. **05 Hours**

7 Analysis of Stability: Concept of stability, stability criterion. Routh test for stability. Theorems of Routh Array test, Conceptual numerical on Routh test for stability. **05 hours**

Text Books

1. Process System analysis and control by Donald R Coughnowr, 2nd Edn.Mc Graw Hill,1991
2. Chemical Process Control by George Stephanopoulos, Prentice Hall of India, 1999

Reference Books

1. Process Control-Peter Harriott, Tata McGraw-Hill Publishing Company Limited, 2004.

Scheme for End semester assessment (ESA)

UNIT	8 Questions to be set of 20 Marks Each	Chapter numbers	Instructions
I	3 Questions to be set of 20 Marks Each	1,2	Solve Any 2 out of 3
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III	2 Questions to be set of 20 Marks Each	6,7	Solve Any 1 out of 2

Program: Biotechnology		
Course Title: Bioprocess Modeling and Simulation		**Course Code: 18EBTE401**
L-T-P: 3-0-0	**Credits: 3.0**	**Contact Hours: 03 Hours/Week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 40	**Examination Duration: 03 Hours**	

Unit I

1.Introduction to modeling:

Introduction, Mathematical Modeling of Bioprocess Engineering System, General Aspects of the Modeling Approach, General Modeling Procedure: Fundamentals uses of mathematical model, scope of coverage, principles of formulation; Fundamental Laws of Modeling: continuity equation, energy equation with examples **05 Hours**

2.Fundamental Laws of Modeling:

Equation of motion, transport equation, equation of state, phase and chemical equilibrium, chemical kinetics; Lumped and distributor parameters with examples **05 Hours**

3. Mathematical models of Biochemical Engineering Systems:

Modeling of Batch reactors, modeling of CSTR, Numericals. Plug flow reactor, Fluidized bed reactor, Reactors used in effluent treatments, packed bed reactor. **05 Hours**

Unit II

4. Use of MATLAB in Process Simulation:

Basics-Data analysis-curve fittings, Numerical integration, Euler and fourth order RungeKutta method, Input and Output in MATLAB. Solving problems using MATLAB by numerical integration, Euler and fourth order Runge Kutta methods. Simulation of CSTR and Batch Reactor, Simulation of Plug flow reactor. **10 Hours**

4.Introduction to Process Design:

Steps involved in process design, Process flow diagram structure and hierarchical approach, importance of Material and Energy balance, selection of unit operations,

05 Hours

Unit III

5.Introduction to process simulation software

Bioprocess design with example: Process Description, Specifying Process Sections, Specifying Equipment Sharing, Initialization of Reaction Operations, Process Analysis, Cost Analysis and Economic Evaluation, Environmental Impact.

05 Hours

6. Use of Super Pro in Process Simulation:

Components and mixtures, Physical and Chemical properties of components, material and energy balance simulation, adding unit operation, scheduling the unit process, process cost estimation, sizing of the unit operation.Case study: Monoclonal antibody production, Enzyme production

05 Hours

Text Books:

1.Luyben W.L., Process Modeling Simulation and Control for Chemical Engineers., McGraw Hill, 1988.

2. Pauline M. Doran, “Bioprocess Engineering Calculation”, Blackwell Scientific Publications.

Reference Books:

1. Kenneth J. Beers. “Numerical Methods for Chemical Engineering Applications in MATLAB®”, Massachusetts Institute of Technology, Cambridge University press 2007 edition.

2. Bailey and Ollis, “Biochemical Engineering Fundamentals”, 2 nd ed.,McGraw Hill, 1986.

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III	2 Questions to be set of 20 Marks Each	5,6	Solve Any 1 out of 2

Program: Biotechnology		
Course Title: Downstream Processing Technology		**Course Code: 19EBTC401**
L-T-P: 4-0-0	**Credits: 4.0**	**Contact Hours: 04 Hours/Week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 50	**Examination Duration: 03 Hours**	

Unit I

1. Introduction

Role and importance of downstream processing in biotechnological processes. Characteristics of biological mixtures, Process design criteria for various classes of byproducts (high volume, low value products and low volume, high value products), Steps involved, case studies, costing of product and numericals

09 Hours

2. Primary Separation Techniques

Cell disruption methods for intracellular products, Removal of insolubles, Biomass (and particulate debris) heat and photosensitive materials (considering lyophilization) separation techniques; Flocculation and Sedimentation, Centrifugation and methods of centrifugation, filtration methods and types of filter media, numericals.

11 Hours

Unit II

3. Membrane separation processes

Membrane – based separations theory; Design and configuration of membrane separation equipment; Concentration polarization and fouling – causes, consequences and control techniques; Applications: Reverse osmosis, Dialysis, Ultra filtration, Micro filtration, Numerical of membrane separation process, Case Studies.

12 Hours

4. Enrichment operations

Precipitation methods with salts, organic solvents, and polymers, Extraction methods for separations. Reversed micellar extraction and Aqueous two-phase extraction, Supercritical extraction; In situ product removal / integrated bio-processing, numericals.

08 Hours

Unit III

5. Product recovery-I

Introduction to chromatography (Van Deemter equation), reversed phase chromatography, Hydrophobic Interaction Chromatography, Ion Exchange Chromatography, numericals.

05 Hours

6. Product recovery-II

Gel Filtration Chromatography, Affinity Chromatography, Polishing Operations: Crystallization, Drying **05 Hours**

Text Books:

1. B. Sivasankar, Bioseparations: Principles and Techniques , Eastern Economy Edit, Prentice-H, 2005

2. P.A. Belter E.L. Cussler, W.S. Hu, Bioseparations: downstream processing for biotechnology, John-Wiley, New York, 1988

Reference Books:

1. BIOTOL, Product Recovery in Bioprocess Technology, VCH, 1990
2. Shuler and Kargi , Bioprocess Engineering , Prentice Hall, 1992
3. Asenjo J. and Dekker M, Separation Processes in Biotechnology , 1993 CRC Press

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III	2 Questions to be set of 20 Marks Each	5,6	Solve Any 1 out of 2

Program: Biotechnology		
Course Title: Bioethics, Safety & IPR		**Course Code:19EBTE401**
L-T-P: 3-0-0	**Credits: 3.0**	**Contact Hours: 03 Hours/Week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 40	**Examination Duration: 03 Hours**	

Unit I

1. Perceptions about Biotechnology: Biotechnology and social responsibility, Positive & negative perceptions of Biotechnology, Public acceptance issues, surveys, areas of public concern for Biotechnology. Socio, ethical, economic and legal aspects of Biotechnology. Public education & Biotechnology. **05Hours**

2. Bioethics: Legality, morality, and ethics, Principles of bioethics: autonomy, human rights, beneficence, justice, equity, etc. Expanding scope of ethics from Biomedical practice to Biotechnology, ethical conflicts in Biotechnology. **05 Hours**

3. Biosafety concept and issues : Rational vs. subjective perception of risks and benefits, Hazards of BT , relationship between risk and hazard, Ethical implications of biotechnology products and techniques, **05 Hours**

Unit II

4. National and International Regulations: Cartagena protocol, OECD consensus documents and Codex Alimentarius; Indian regulations – EPA act and rules, guidance documents, regulatory framework – RCGM, GEAC, IBSC and other regulatory bodies; category of rDNA experiments; field trails – biosafety research trials – standard operating procedures - guidelines of state governments; GM labeling – Food Safety and Standards Authority of India (FSSAI)

10Hours

5. Biosafety & Management: Laboratory associated Biosafety practices, assessment of biohazard, Biosafety levels,. Risk analysis and assessment, Containment levels-physical, biological containments,. Good manufacturing practice and Good lab practices (GMP and GLP). **05 Hours**

Unit III

6. Intellectual Property rights: Introduction to history of GATT, WTO, WIPO and TRIPS; Introduction to IPR, Types of IP: Patents, Trademarks, Copyright, Design & Related Rights. Plant variety protection, Traditional knowledge, breeders rights, Geographical indications, Biodiversity and farmers rights. Patenting in biotechnology, case studies.

05 Hours

7. Food, Agri and Pharma Sector: The GM-food debate and biosafety assessment procedures for biotech foods including transgenic food crops, case studies- Golden Rice and Flav Savr

Tomatto. Biosafety assessment of pharmaceutical products such as drugs/vaccines etc. Biosafety issues in Clinical Trials. **05 Hours**
Text Books 1.Bioethics & Biosafety- Sateesh MK, I.K.International Publishing House 2.Intellectual Property rights on Biotechnology – Singh K, BCIL, New Delhi. 3.Biotechnology: Expanding Horizons - B D Singh, Kalayani Publishers, 2010
Reference Books: **1.** Bioethics & Biosafety – R. Rallapalli & Gita Bali, APH publication, 2007 **2.** Safety considerations for Biotechnology-Paris, OECD publications

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II	3 Questions to be set of 20 Marks Each	4,5	Solve Any 2 out of 3
III	2 Questions to be set of 20 Marks Each	6,7	Solve Any 1 out of 2

Program: Biotechnology		
Course Title: Industrial Biotechnology		Course Code: 20EBTE401
L-T-P: 3-0-0	Credits: 3.0	Contact Hours: 03 Hours/Week
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hours: 40	Examination Duration: 03 Hours	

Unit I

1 Introduction

History of fermentation products, Range of fermentation process: Traditional approach: biomass, enzymes, metabolites and biotransformation; Modern fermentation process: rDNA products, animal cell culture: therapeutic proteins, monoclonal antibodies; application of system biology approach; generalized representation of typical fermentation process.

05Hours

2. Isolation and improvement of industrial microorganisms

Isolation methods: Primary screening and secondary screening; Improvement of industrial microorganism: selection of induced mutants for primary and secondary metabolites, isolation of revertant mutants, use of rDNA systems, and improvement by other properties.

05Hours

3. Fermentation products

Beverages(beer), Ethanol, Aminoacids, enzymes(lipase/protease), penicillin, therapeutic proteins, monoclonal antibodies and vaccines.

05Hours

Unit II

4 Bioreactor configuration-I

CSTR with recycle, CSTR in series, Airlift reactor, Fluidized bed bioreactor, bubble column bioreactor, packed bed bioreactor, tickle bed bioreactor, deep jet bioreactor, rotating disc bioreactor.

05Hours

5. Bioreactor configuration-II

Animal cell bioreactors:- Homogeneous reactor: Solid and macro porous micro carriers bioreactor; Heterogeneous reactor: Hallow fiber bioreactor, Packed glass bed bioreactor, fluidized bed bioreactor, cell encapsulation; Disposable bioreactor: Wave bioreactor and stirred bag bioreactor.

05Hours

6. Advance downstream processing

Process integration in product recovery, large scale refolding of therapeutic proteins, advanced membrane technology, Chromatography: column quantification and validation, AKTA purifier, reversed micellar technique for bio separation Single use technology in purification.

05Hours

Unit III

7. Fermentation monitoring and control:

On-line and off-line monitoring instruments, Bioprocess modeling for control, Estimation technique: Traditional method, linear black-box model and non-linear model; control strategies for fermentation, real time data analysis: Raman spectroscopy.

05 Hours

8. Fermentation data analysis:

Introduction, classification of fermentation measurement and quantities, calculation of metabolites, estimation of unmeasured variables, calculation of integral and averaged variable, physiological variable and pattern recognition technique, SIMCA software.

05Hours

Text Books:

1. L.E.Casida,JR ,Industrial Microbiology, New Age International (P) Ltd Publication.
2. Prescot and Dun, Industrial Microbiology, McGraw-Hill Book Company, Inc. New York

Reference Books:

1. D.Lanch,Drew,Wang, Comprehensive Biotechnology-Volume 3,Elsevier Publication.
2. George T. Austin, Nicholas Basta; Shreves Chemical Process Industries Handbook; McGraw Hill Professional, 1998

Scheme for End Semester Assessment (ESA)

UNIT	8 Questions to be set of 20 Marks Each	Chapter numbers	Instructions
I	3 Questions to be set of 20 Marks Each	1, 2,3	Solve Any 2 out of 3
II	3 Questions to be set of 20 Marks Each	4,5,6	Solve Any 2 out of 3
III	2 Questions to be set of 20 Marks Each	7a,7b	Solve Any 1 out of 2

Program: Biotechnology		
Course Title: Bio-business & Entrepreneurship		**Course Code: 20EBTE402**
L-T-P: 3-0-0	**Credits: 3.0**	**Contact Hours: 3 hours/week**
ISA Marks:50	**ESA Marks:50**	**Total Marks:100**
Teaching Hours:40	**Examination Duration:3 hrs**	

Unit-I

1. Entrepreneurship

Concept of Entrepreneurship - Development of Entrepreneurship; Stages in entrepreneurial process; Role of entrepreneurs in Economic Development; Characteristics of successful Entrepreneur, Classification of Entrepreneurs, Myths of Entrepreneurship, Entrepreneurial Development models, Entrepreneurial development cycle, Problems faced by Entrepreneurs. Entrepreneurship in India: Small scale industries: Definition; Characteristics; Need and rationale. Objectives; Scope; Introduction to bio-business, from the Indian context, SWOT analysis of bio-business.

10 hours

2. Social Responsibilities of Business

Meaning of Social Responsibility, Social Responsibilities of Business towards Different Groups, Social Audit, Business Ethics and Corporate Governance Institutional Support for Business Enterprises: Introduction, Policies & Schemes of Central Level Institutions, State Level Institutions.

05 hours

Unit-II

3. Entrepreneurship opportunity in biotechnology

Business opportunity, Essential requirement, marketing strategies, schemes, challenges and scope-with case studies on entrepreneurship opportunities in different domains of Biotechnology (Agri biotechnology, industrial Biotechnology, food biotechnology, Biopharma, Nutraceuticals. etc).

05 hours

4. Project management, technology management and startup schemes

Meaning of Project; Project Identification; Project Selection; Project Report; Need and Significance of Report; Contents; Formulation; Guidelines by Planning Commission for Project report; Network Analysis; Errors of Project Report; Project Appraisal. Identification of business opportunities: Market Feasibility Study; Technical Feasibility Study; Financial Feasibility Study & Social Feasibility Study.

10 hours

Unit-III

5. Startup Schemes

Building Biotech business challenges in Indian context-biotech partners (BIRAC, DBT, Incubation

centers. Etc.), operational biotech parks in India. Indian Company act for Bio business-schemes and subsidies. Patent expiry and Entrepreneurship opportunity, Principles of Technology leasing, licensing and transfer, Business incubation support schemes, Successful startups-case study.

05 hours

6. Funding Opportunities

Startup schemes in Indian government Sources of Funding for startups. Crowd funding, Self-funding, Venture Capitalists, Angel Investment. Banking support for startup business. Types of companies: Sole proprietorship company, Partnership company, Private Limited, Limited company etc.

05 hours

Text Books:

1. Principles of Management – P. C.Tripathi, P.N. Reddy – Tata McGraw Hill,
2. Entrepreneurship Development - S.S.Khanka - S.Chand & Co.
3. Project Management by Sahni, Ane Books.

Reference books

1. Management Fundamentals - Concepts, Application, Skill Development - Robers Lusier - Thomson
2. Project Management for Business & Technology, Nicholas, PHI.

Scheme for End Semester Assessment (ESA)

UNIT	8 Questions to be set of 20 Marks Each	Chapter numbers	Instructions
I	3 Questions to be set of 20 Marks Each	1,2	Solve Any 2 out of 3
II	3 Questions to be set of 20 Marks Each	3,4	Solve Any 2 out of 3
III	2 Questions to be set of 20 Marks Each	5,6	Solve Any 1 out of 2

Program: Biotechnology		
Course Title: Numerical Methods and Differential Equations		Course Code: 20EMAB205
L-T-P: 4-0-0	Credits: 4.0	Contact Hours: 04 Hours/Week
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hours: 40	Examination Duration: 03 Hours	

Unit I

1. Interpolation techniques

Finite differences, Forward, Backward and central difference Operators. Newton Gregory forward and backward interpolation formulae. Stirling's formula for central difference. Newton's divided difference formula for unequal intervals.

08 Hours

2. Numerical Solution of Partial Differential Equations

Introduction, Classification of PDE, Parabolic, Elliptic and Hyperbolic Partial differential equations, Introduction to finite difference approximations to derivatives, finite difference solution of parabolic PDE, explicit and implicit methods, finite difference method to Elliptic PDE-initial –boundary vale problems, Hyperbolic PDE-explicit method. Engineering problems: Temperature distribution in a heated plate, steady-state heat flow and vibration of a stretched string.

12 Hours

Unit II

3. Matrices and System of linear equations

Introduction to system of linear equations, Elementary row transformations, Rank of a matrix, Consistency of system of linear equations, solution of system by (i) Direct methods-Gauss elimination, Gauss Jordon method (ii) Iterative method - Gauss-Seidel method. Eigen values and Eigenvectors of a matrix. Largest Eigen value and the corresponding Eigenvector by power method. Engineering problems. **08 Hours**

4. Introduction to Statistics

Introduction, Scope of biostatistics, Variables, Measurement scales, Ordered array, Graphical representation of data: Bar Chart, Line chart, histogram, frequency curve, Ogive curves. Descriptive statistics: Measure of central tendency (arithmetic mean, median, mode, quartiles); Measures of dispersion (Quartile deviation, Standard deviation, coefficient of variation), Measure of skewness (Pearson and Bowley's) **12 Hours**

Unit III

5. Introduction to Laplace transform and Solution of Differential Equations

Definition, transforms of elementary functions- transforms of derivatives and integrals-Properties. Periodic functions, Unit step functions and Unit impulse functions. Inverse Transforms- properties-Convolution Theorem. Applications to differential equations

10 Hours
Text Books: 3. **Numerical methods for Engineers,** Chapra S C and Canale R P, 5ed, TATA McGraw-Hill, 2007 4. **Advanced Engineering Methods,** Kreyszig E. 8Ed, John Wiley & sons, 2003. 5. **Applied Statistics and Probability for Engineers, Douglas Montgomery, George Runger, 6Ed, John Wiley, 2014**
Reference Books: 1. **Introduction to Probability and Statistics: Principles and Applications for Engineering and Computing**, J.Susan Milton, Jesse C Arnold, , 4, TATA Mc-Graw Hill Edition, 2007 2. **Fundamentals of Mathematical Statistics**, Gupta S.C and Kapoor V.K, 11Ed, Sultan Chand & Sons, New Delhi, 2002 3. **Higher Engineering Mathematics**, Grewal B S, 38ed, Khanna Publication, New Delhi, 2001.

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I	3 Questions to be set of 20 Marks Each	1,2	Solve Any 2 out of 3
II	3 Questions to be set of 20 Marks Each	3,4	Solve Any 2 out of 3
III	2 Questions to be set of 20 Marks Each	5	Solve Any 1 out of 2

Program: Biotechnology		
Course Title: Biostatistics		**Course Code: 20EMAB210**
L-T-P: 3-1-0	**Credits: 4.0**	**Contact Hours: 03 Hours/Week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 40	**Examination Duration: 03 Hours**	

Unit I

1. Bivariate Distribution Fitting of curves

Introduction to biostatistics, Review of Central tendency and Dispersion, Correlation, linear regression, Curve fitting (Nonlinear and Exponential curves) **05 Hours**

2. Probability

Definition of probability, addition rule, conditional probability, multiplication rule, Baye's rule, sensitivity, specificity, predictive value positive and negative, Probability in Genetics: Punnett square, Hardy - Weinberg law, Wahlund's Principle **05 Hours**

3. Probability distributions

Discrete probability distributions - Binomial, Poisson, Continuous Probability Distribution – Normal, Exponential, Gamma distribution

05 Hours

Unit II

4. Sampling and Statistical Inference

Introduction, Sampling, Sampling distribution, sample size determination, Confidence intervals, Tests of hypothesis, p-value, t-test for single mean, difference of mean (with equal variance and unequal variance), paired t-test, Chi Square test for goodness of fit and independence of attributes, analysis of variance (one-way and two-way classifications). Case studies of statistical designs of biological experiments (RCBD, RBD)

08 Hours

5. Design of Experiments-1

Introduction, OFAT, 2^2 and 2^3 factorial experiments: Data table, Graphical representation, Main and interaction effects, ANOVA Table **07 Hours**

Unit III

6. Design of Experiments -2

Fractional factorial design, Placket-Burman design, Response Surface Methods-Central Composite Design

05 Hours

7. Population Growth Models

Introduction, Discrete time and continuous growth, Density Independent growth model: Geometric and Exponential growth model, Density dependent growth: Logistic growth model **05 Hours**

Text Books:

6. **Applied Statistics and Probability for Engineers,**Douglas Montgomery, George Runger, 6Ed, John Wiley, 2014
7. **Introduction to Probability and Statistics: Principles and Applications for Engineering and Computing,**J.Susan Milton, Jesse C Arnold, , 4, TATA Mc-Graw Hill Edition, 2007
8. **Mathematical Models in Biology and Medicine**, Kapoor J.N, EWP New Delhi, 2000

Reference Books:

4. **Fundamentals of Mathematical Statistics**, Gupta S.C and Kapoor V.K, 11Ed, Sultan Chand & Sons, New Delhi, 2002

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III	2 Questions to be set of 20 Marks Each	6,7	Solve Any 1 out of 2